

Semi-Annual Status Report
Theoretical Investigation of Radiation Damage
in Solar Cells

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Introduction

Theoretical investigation of the radiation damaged solar cells has been continued from two different points of view. One is to know the effects of damages caused by radiation on the electric properties of semiconductors for various concentration ranges and for various species of damages. The other is to study how the radiation damages are annealed with elapse of time as the temperature of the sample is increased.

Current Research

Impurity Band Conduction

A paper entitled "Impurity Conduction in the Intermediate Concentration Region" by H. Nishimura was published in the Physical Review Vol. 138 No. 3A, pp A815-821 (1965). In this paper the electric conduction in the intermediate concentration region is attributed to the formation of a band due to interaction of the negatively charged donors. The theory can explain fairly well the observed temperature dependence of the conductivity.

Another paper entitled "On the Configurational Average of the Green's Function for Liquid Metals" by J. B. Jalickee, T. Morita and T. Tanaka was published in the Philosophical Magazine, Vol. 12 No. 115 p.209 (1965). In this paper a general theoretical technique of calculating the band structure in highly random systems is discussed. The words "for Liquid Metals" in the title mean the random distribution of atoms in the system and the method is directly applicable to impurity semiconductors.

Present work involves an extension of the method of Green's function

in order to obtain a theoretical expression which is valid in all concentration regions of the electric conductivity in impurity semiconductors. It is expected that this work will be completed within the next three months.

Another subject of investigation which is also under progress is the theory of non-linear transport coefficients. Reflection of a laser beam on the semiconductor surface gives useful information about the electronic properties of semiconductors. Recently various non-linear effects are also observed experimentally. We have formulated a basic theory of non-linear transport coefficients, and currently are trying to apply the theory to specific systems. The formulation of the general theory will be published within the next three months.

Study of the Annealing Kinetics

It is well known that radiation damages in solar cells are annealed with elapse of time when the temperature of the sample is increased. But the annealing of one damage species is strongly influenced by the amount of other damage species and also by the rates at which other species are annealed. In other words the time rates of change of the number of damages are described by a set of highly non-linear differential equations. Since there is no standard technique of solving set of non-linear equations established, various investigators have been trying to solve the problem by various methods. Recently we have found a very powerful and accurate method of solving a set of non-linear equations. This method is applied to the case of the kinetics of vacancy-inter-

stitial annihilation with vacancy impurity trapping. This model has application to the mechanism of Si-A center or Si-E center formation, and indeed, to any vacancy impurity trapping mechanism which obeys the chemical laws of mass action. In particular the method is applied to a test case in which the exact solution is known, and it is found that the method reproduces the solution within one percent at $t=10^6$ sec. later. The method has been further modified and been applied to more general cases. It is expected that this work will be completed within the next three months. This work has been carried out with close cooperation of Dr. P. H. Fand and Mr. M. M. Sokoloski of NASA Goddard Space Flight Center.

Personnel

Tomoyasu Tanaka	Principal investigator. Full time during summer months. Visit NASA Goddard Space Flight Center regularly and participate in Seminars and Discussions.
Hisashi Nishimura	Post Doctoral Fellow, Full time. Sept. 1964-Aug. 1965.
Kishin Moorjani	Post Doctoral Fellow, Full time. Sept. 1965-present. Working on the optical properties and non-linear effects in semiconductors.
J.B.Jallicee	Full time graduate student working on the theory of impurity conduction.
S. H. Brown	Full time graduate student working on the theory of impurity conduction.